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CRITICALITY EXPERIMENTS FACILITY: A NEW BEGINNING TO ANSER SOME OLD (AND NEW) QUESTIONS

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ABSTRACT

After seven years, the former Los Alamos Critical Experiments Facility (LACEF), or Pajarito Site, has reopened for business as the Criticality Experiments Facility (CEF) at the Nevada National Security Site (NNSS).

Four critical assembly machines (Comet, Planet, Flat-Top, and Godiva-IV) made the journey from Los Alamos to the NNSS. All four machines received safety system upgrades along with new digital control systems. Between these machines, systems ranging from the thermal through the intermediate to the fast spectrum may be assembled. Steady-State, transient, and super-prompt critical conditions may be explored.

Reconstitution of the unique capabilities at CEF ensures the viability of

- The Nuclear Renaissance,
- Stockpile Stewardship, and
- The next generation of criticality experimentalists.

In this paper, the capabilities and planned experimental program of the CEF are discussed.

Key Words: Comet, Flat-Top, Godiva-IV, Planet

1 INTRODUCTION

The mission of the CEF at the Device Assembly Facility (DAF) is to conduct experiments on critical assemblies with fissile material at or near criticality in order to explore reactivity phenomena, and to operate the assemblies in the regions from subcritical through delayed critical. One critical assembly, Godiva-IV, is designed to operate above prompt critical. The critical assemblies contain fissile and other materials that are used to carry out research and development activities in support of criticality safety, accident simulation and analysis, reactor design, dosimetry evaluation, and other programmatic needs.

2 CEF CAPABILITIES

2.1 Planet

Planet (See Figure 1.) is a general purpose, vertical assembly machine. Planet can be used to investigate the criticality characteristics of different geometries and compositions of fissile material. Both heterogeneous and homogeneous arrangements of fissile materials with different types and quantities of moderator/reflector materials can be used.

Planet was originally built as a duplicate for Comet when demand for the machines resulted in programmatic conflicts, particularly in the area of criticality safety training. Hence, Planet was specifically designed to provide easy access for students and instructors for hand-stacking operations and the demonstration of the effect of materials such as moderators, reflectors, and poisons.

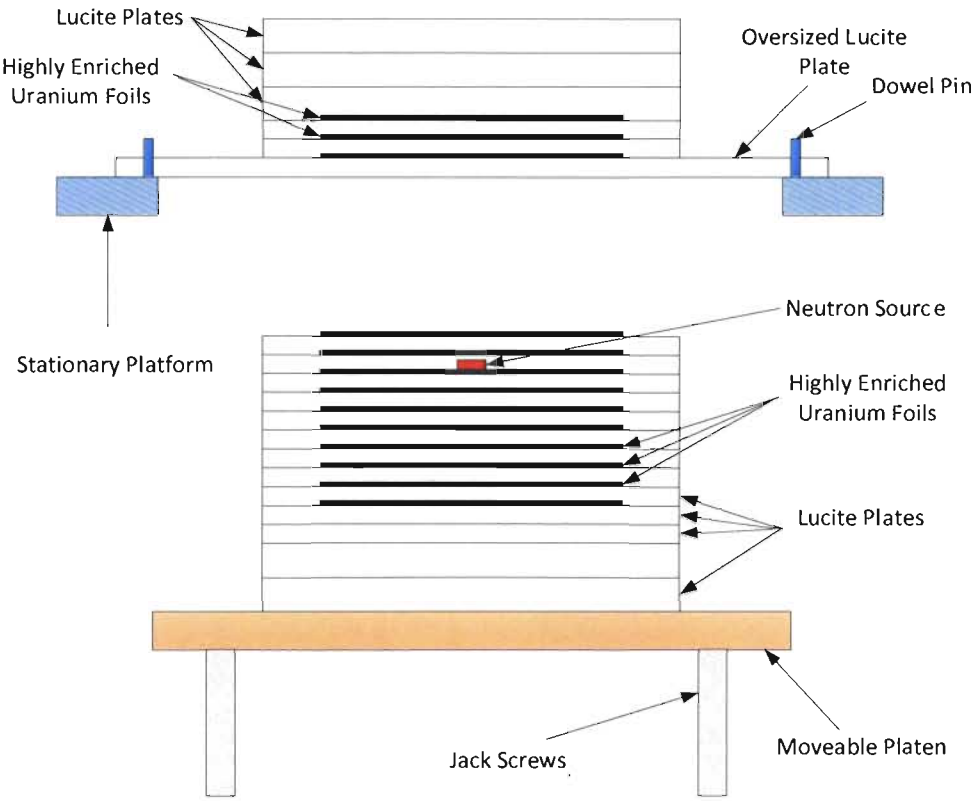

Figure 1. Planet schematic with class foils.

2.2 Comet

Comet (See Figure 2.) is a large capacity general-purpose vertical assembly table. Coarse assembly is achieved by the stroke of two hydraulic rams with fine assembly made by means of a ballslide driven by a computer-controlled stepper motor. Disassembly, hence shutdown, is achieved by gravity which forces the hydraulic ram table to descend. Comet is capable of supporting much larger experiments than Planet.

2.3 Flat-Top

Flat-Top (See Figure 3.) is a natural-uranium-reflected, benchmarked, fixed-geometry critical assembly machine that can accommodate plutonium or uranium cores. The fast neutron spectrum is used to provide benchmarked neutronic measurements in spherical geometry with different fissile driver materials. Key missions for Flat-Top include fundamental reactor physics studies, sample irradiation for radiochemical research, actinide minimum critical mass studies, detector calibration, and training.

Table I. Flat-Top Fluxes and Fluence

Flat-Top	Power (kW)	Central Flux ($n\ cm^{-1}\ s^{-1}$)	Central Fluence (1 h) ($n\ cm^{-2}$)	Flux at 1 m ($n\ cm^{-1}\ s^{-1}$)
Pu	0.1	$12.0\ 10^{10}$	$4.4\ 10^{14}$	$4.0\ 10^{7}$
U(93)	0.1	$5.6\ 10^{10}$	$2.0\ 10^{14}$	$2.6\ 10^{7}$

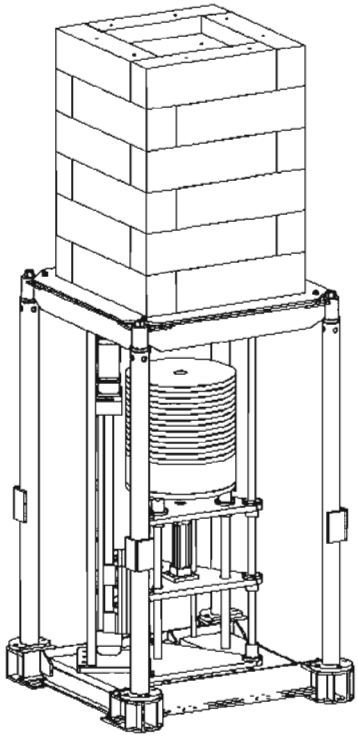

Figure 2. Comet schematic with Zeus experiment.

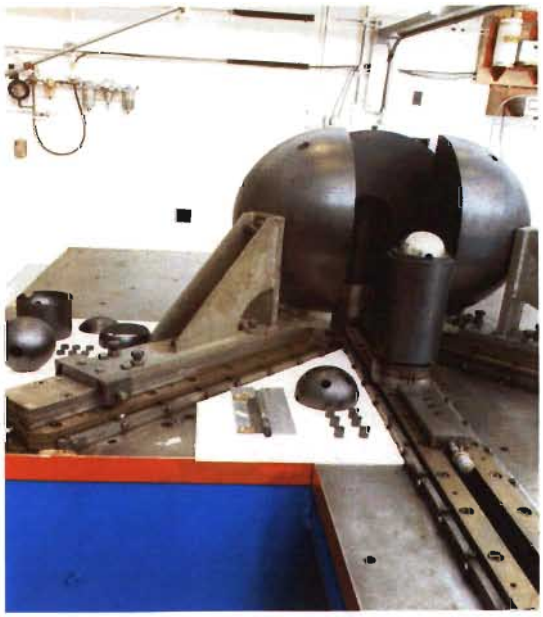

Figure 3. Flat-Top.

2.4 Godiva-IV

Godiva-IV (See Figure 4.) is a metal fast-pulse critical assembly machine, which can be operated in a steady state mode or to produce a super-prompt critical nuclear excursion for materials testing. Godiva is fueled with enriched uranium (93%) alloyed with 1.5% molybdenum by weight. When assembled, this core is comprised of eight interlocking plates, a safety block, two control rods and a burst rod. The core, when fully assembled, is very nearly a clean, right circular cylinder. The assembly is designed with no reflector and is designed to have a very short neutron lifetime. These features result in a very high power and short burst of neutrons.

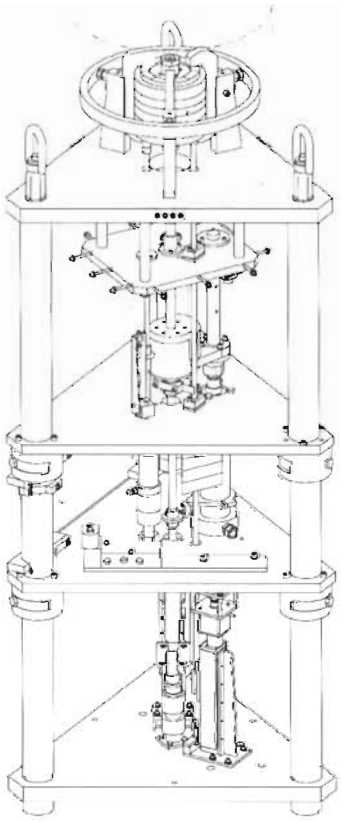

Figure 4. Godiva-IV schematic.

Table II. Godiva-IV Fluxes and Fluence

Godiva-IV	Power (kW)	Central Flux (n cm^{-1} s^{-1})	Central Fluence (10 h) (n cm^{-2})	Flux at 1 m (n cm^{-1} s^{-1})
U(93)	1.0	$1.7\ 10^{11}$	$6.0\ 10^{15}$	$4.0\ 10^{8}$

Table III. Godiva-IV Neutronic Properties for 300 °C ΔT Burst

Godiva-IV	Burst Width (μs)	Burst Energy (MJ)	Leakage Neutrons	Central Flux (n cm^{-1} s^{-1})	Central Fluence (n cm^{-2})	Flux at 1 m (n cm^{-1} s^{-1})
U(93)	1.0	1.8	$8.9\ 10^{16}$	$1.7\ 10^{11}$	$3.3\ 10^{14}$	$2.3\ 10^{16}$

2.5 General Purpose Nuclear Material Handling

CEF is the sole remaining facility in the United States capable of conducting general-purpose nuclear materials handling including the construction and operation of high-multiplication assemblies, delayed critical assemblies, and prompt critical assemblies. In addition to the facilities and nuclear material inventory, CEF is supported by the Los Alamos National Laboratory Advanced Nuclear Technology Group consisting of approximately 80 full-time personnel representing an unparalleled national resource of expertise.

3 PLANNED PROGRAM OF EXPERIMENTS

Activities planned for CEF include the following:

- Hands-On Nuclear Criticality Safety Training for operators, supervisors, and criticality safety engineers
- Intermediate energy spectrum experiments
- Criticality properties of actinides
- Dosimetry studies
- Accident analysis benchmarks
- Subcritical methods development
- Reaction rate and fission-product yield measurements
- Experimental error reduction and reproducibility measurements
- Benchmark critical with structural material diluents

Currently, CEF is executing the startup plan for all operations. General nuclear material handling, Planet, and Comet have been successfully restarted. Flat-Top and Godiva-IV will undergo startup testing in the next few months. Full CEF availability is anticipated in March 2012.

4 SUMMARY

Four critical assembly machines have been installed at the Criticality Experiments Facility located at the Nevada National Security Site. Planet and Comet have completed startup testing and are authorized for use. Flat-Top and Godiva-IV are scheduled to be operational before March 2012, at which time all CEF capabilities will be operational. Requests for integral experiments may be made via the following link: http://ncsp.llnl.gov.